

Implementation of Augmented Reality Technology as a Learning Media for Car Engine Components

Cipta Andika Putra Pratama
Yogyakarta University of Technology
Yogyakarta, Indonesia

Joko Aryanto
Yogyakarta University of Technology
Yogyakarta, Indonesia

ABSTRACT

The rapid advancement of technology due to the phenomenon of the Industrial Revolution 4.0. There is a need for innovation in technology development to package the current learning process to be more effective, one of which is the development of learning media which is an important part of the learning process and of course directed at meaningful learning that encourages students to develop 21st Century skills as an urgency in the field of education [1]. Learning media is one of the things that affects student learning outcomes. It holds that media (literacy) education and activity-oriented learning in educational institutions and the use of (digital) media in classroom teaching have the potential to arouse learners' emotions and, in doing so, to stimulate learners' interest and encourage their active participation [2]. With current technological developments, Augmented Reality can be one of the learning media that can make users interested and interact while learning [3]. Yet, these technologies are in developing stage and require massive investment and mass customization to meet the high demand in education [4]. Seeing this, the idea arose to develop learning media for the introduction of gasoline engine components by utilizing android-based Augmented Reality technology. The purpose of this application is to facilitate the learning process for students at Vocational High Schools.

General Terms

Android, Unity 3D, Vuforia, C#

Keywords

Augmented Reality, Otomotive Education, Car Component, Markerless, Markerbase

1. INTRODUCTION

In this era, technology is developing very rapidly, the importance of this technology makes people's lives lighter. Among the new options brought by digitalization, the one analyzed in this work corresponds to the use of augmented reality [5] in school learning. Augmented reality (AR) is a contemporary visualization technology that extends sensory perception through digital objects [6]. However, the application of Augmented Reality in education as learning media is still rarely used [7]. Basically, humans have high basic potential and will continue to develop if honed continuously, therefore it is important to make the learning process interactive and fun.

Learning in vocational high schools is often practical and requires a lot of additional props. The use of Augmented Reality technology can facilitate the introduction process in learning and provide an interactive atmosphere. This technology is not made to replace the practicum process, but to facilitate the introduction process. With AR, students are given the opportunity to interact directly with the content and inspect it from different angles [8].

The development of Augmented reality-based learning media for the introduction of car engine components helps review the material that has been taught by the teacher, and helps visualize how car engine components work. A key step to realize user requirements elicitation in product development is to conduct user studies with prototypes. However, accurate user requirements elicitation can be very challenging in the specific domain of interactive devices, especially when the device is at an early stage of development, such as function identification or feature prioritization [9]. The objectives, processes and strategies for prototyping have been explored by design researchers for the purpose of understanding and guiding best practice [10]. Various programming languages are playing increasingly critical roles in prototyping the backend software, connectivity, and user interfaces [11]. As a result, we have realized a system that allows students to easily compare images in real 3D objects with virtual 3D objects while learning [12]. Planes are ubiquitous in built environments as walls, ceiling and floor slabs and as components of other objects such as square columns [13]. This research was develop using Unity with C# programming language. This aims to improve the quality of student learning cause AR media is more effective in improving student skills [14].

2. RESEARCH METHOD

The proposed system analysis in the research of mobile augmented reality applications as a learning media for car engine components can be seen in the figure below.

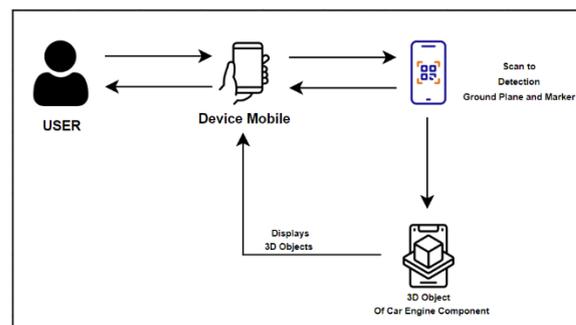


Fig. 1 Architecture Diagram

In the fig. 1, it can be seen that a user using a smartphone can run the system by detecting objects through the camera sensor on the smartphone to detect the ground plane. The 3D object of the machine component will appear on the smartphone screen and provide information about the component and the description of the component.

2.1 Data Collection Procedure

In collecting data, several procedures were carried out to obtain data, including the following.

2.1.1 Direct Observation (Observation)

The process of obtaining data in this study was carried out by searching for references with keywords that are in accordance with the theme being compiled in the research of Mobile Augmented reality Applications as a Learning Media for Car Engine Components. Data sources are obtained from publication manuscripts and papers from publications in each repository through online searching.

2.1.2 Interview

At this stage, data is obtained from the results of previous interviews with teaching staff who teach basic automotive engineering courses, as well as obtaining reference materials from journals, books and other sources on the internet. For materials related to interaction components in the form of 3D objects and animation, data is obtained from the internet and questions and answers with experts in this field.

2.1.3 Data Collection Time

The time used by researchers for research on mobile augmented reality applications as a learning media for car engine components is carried out from the date of issuance of a research permit in a period of approximately 3 (three) months, 1 month of data collection and 2 months of data processing which includes presentation in the form of reports and the guidance process takes place.

2.2 System Design Logic

Logic design is a process carried out to identify problems by creating a function structure and a combination of appropriate working principles so as to get the correct solution principle. the structure and working principles can be described in the form of diagrams that can describe the structure clearly and easily understood. System planning is an advanced stage after defining system requirements. System planning is used to provide a clear and complete picture of the system to be built.

2.2.1 Flowchart

The flow of processes that occur in augmented reality mobile applications as a learning media for car engine components can be seen. The process begins with the appearance of menu options, namely start AR/scan mode, material, how to use (tutorial), about and exit. If the start AR/scan mode menu is selected, the AR Camera will open and will identify the detected ground plane. If the ground plane is identified, a 3D object will be displayed on the AR Camera along with display controls. If the ground plane is not identified, the AR Camera will re-identify it. If the AR menu/second scan mode is selected, the AR Camera will open and will identify the detected marker.

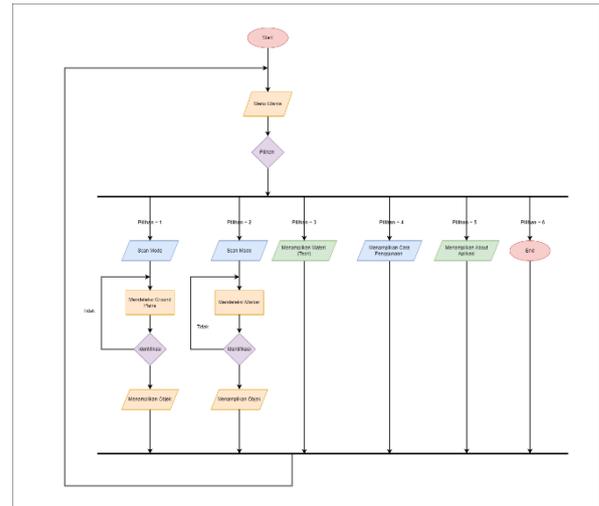


Fig. 2 Flowchart

If the marker is identified, a 3D object will be displayed on the AR Camera along with the view controls. If the marker is not identified, the AR Camera will identify it again. Then if you select the material menu, a scene containing material from the application will be displayed. Then if you choose the help menu, users will be given instructions or help using Augmented reality-based applications. When the user selects the about menu, it will appear about the description of the application and who made the application. If you want to end the application, the user can select the exit menu.

2.2.2 Use Case Diagram

Use Case Diagram on mobile augmented reality applications as learning media for car engine components can be seen in Fig. 4. In the system there are five use cases, namely the main menu use case, scan mode, material, how to use, about the application and exit. From each use case, a scenario will be determined to explain the sequence of steps in the process carried out by each use case. Both what actors do to the system and what the system does to actors.

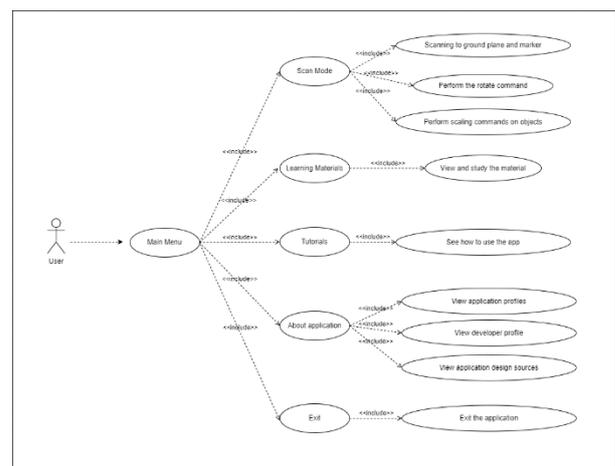


Fig. 4 Use Case Diagram

2.2.3 Activity Diagram

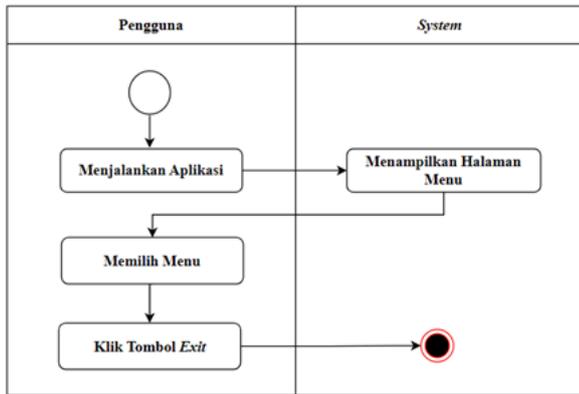


Fig. 5 Activity Diagram

2.3 Physical Design

Physical design is the implementation of the application interface design that is compiled. Includes the display of the menu structure contained in the augmented reality mobile application as a learning media for car engine components.

2.3.1 Splash Screen Display

the initial display that first appears when the user runs the application

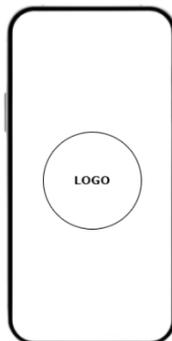


Fig. 6 Splash Screen Display

2.3.2 Main Menu Display

On the main menu display there is a scan AR menu for markerles, material menu, tutorial menu, and about menu, scan AR at the top is a scan AR menu used for markerbase mode.

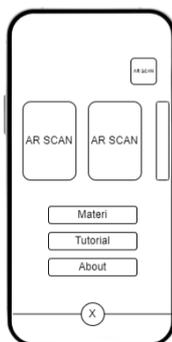


Fig. 7 Main Menu Display

2.3.3 Material List Display

In the material list view, there are many buttons to go to the material details of the engine components.

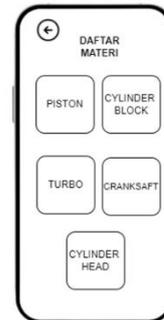


Fig. 8 Material List Display

2.3.4 Scan Code Menu Display

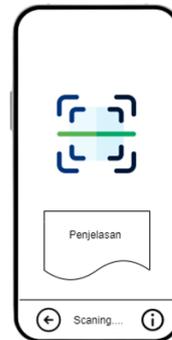


Fig. 9 Scan Code Menu Display

The display includes objects to be shown and explained, as well as buttons to play and activate the audio.

2.3.5 Tutorial Menu Display

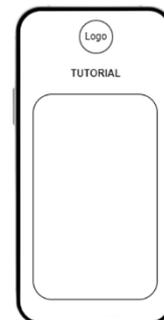


Fig. 10 Tutorial Menu Display

there is a display in the form of an explanation of how this application is used. The display contains the stages of how this application is run until running the scan menu.

2.3.6 About Menu Display



Fig. 11 About Menu Display

on this page there is an explanation of this application

3. RESULT AND DISCUSSION

3.1 Assumption

The user of the application can use a smartphone to operate it. students can directly scan and 3D objects that explain the material will appear.

3.2 Hypothesis

This hypothesis is based on assumptions obtained and proven in the research stage. This research hypothesizes that “Augmented Reality Mobile Application as a learning media for car engine components can improve the quality of student learning”.

3.3 Run an Experiment

This section will explain the concept of prototype design and Augmented Reality program development for interactive learning and explain the basic design of the application output. Prototyping and program development is done using Unity and Vuforia database with C# programming language. This chapter describes the appearance of the application, the database, and the function of each menu.

3.3.1 Login Page

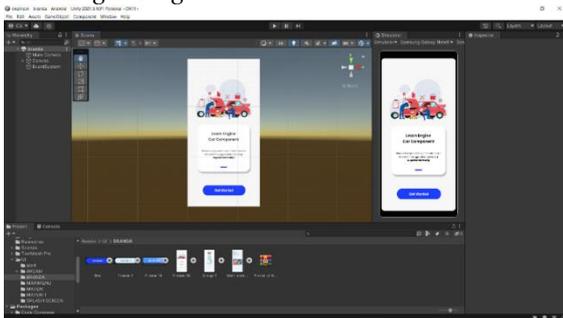


Fig. 12 Login Page

The implementation of the home page is an application of the page design that will display a welcome greeting and application title and there is a main button, namely Start. In order for the button to work, it is necessary to add source code to the button.

3.3.2 Main Menu Page

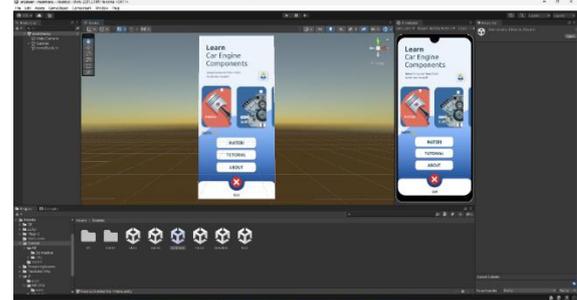


Fig. 13 Main Menu Page

On the main menu page there is an Ar scan markerless button that can be scrolled to select the object to be studied and display the 3d object. The second Ar Scan button is a button that can be used for markerbase mode which has the same function but different technology used. The tutorial button is a button that will direct the user to the usage instructions page. The about button is a button that can direct users to the page about the application designer and about the application. The X button is a button used to exit the application.

3.3.3 Material Page



Fig. 14 Material Page

The material page is displayed when the material button is pressed Implementation of the material menu page to bring up the engine component material clearly.

3.3.4 Markerless AR Scan Menu Page

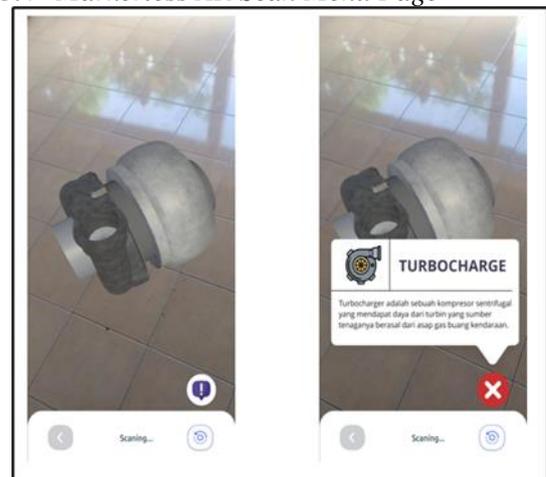


Fig. 15 Markerless AR Scan Menu Page

Implementation of the AR scan menu page to bring up 3D objects of car engine components and their descriptions. There is an information button that is used to display information

about the object. There is a rotation button that is used to rotate the 3D object that appears on the layer, there is also an audio button to run audio information on the application and there is a back button that goes to the main page.

3.3.5 Markerbase AR Scan Page

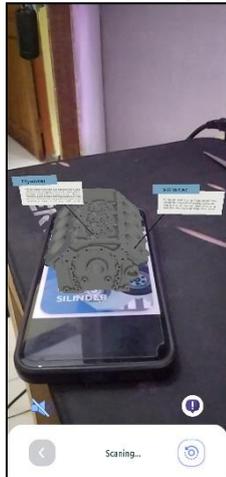


Fig. 16 Markerbase AR Scan Page

The AR scan markerbase menu page will appear when the AR scan button on the main menu page is pressed. Implementation of the AR scan markerbase menu page to bring up 3D objects of car engine components and their descriptions by detecting markers that have been integrated with the application. There is an information button that is used to display information about the object. There is a rotation button that is used to rotate the 3D object that appears on the layer, there is also an audio button to run audio information on the application and there is a back button that goes to the main page.

3.3.6 Tutorial Page

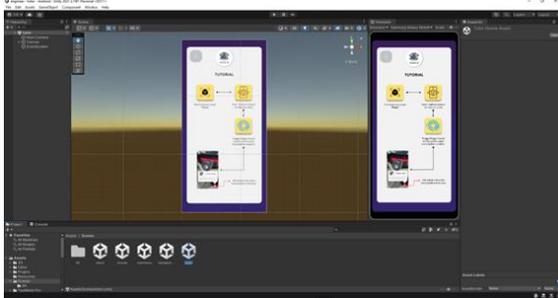


Fig. 17 Tutorial Page

Implementation of the tutorial menu page to display how to use the Augmented reality application. There is a back button that goes to the main menu page.

3.3.7 About Page

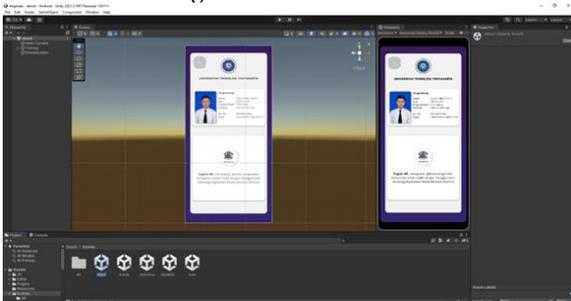


Fig. 18 About Page

Implementation of the about menu to display information on who created the application and application description. There is a Back button to go to the main menu page.

3.4 Discussion of Result

Software testing is the main technology to ensure the quality of the software [15]. There is a survey that indicates 45% of development cost is spent on software testing [16]. At this stage, after the implementation of the application program is complete, the next process is to test the program, whether there are errors or not. Testing is done using two types of smartphones with different specifications. The smartphones used are Xiaomi Redmi Note 7 and Xiaomi Redmi Note 8 Pro. These two devices have significant hardware differences, in terms of processor performance and RAM capabilities that can be a variation for AR Engine system testing.

Table 1 Main Menu Test Result

Test Class	Test Scenario	Expected Results	Results
Main Menu	Selecting the menu AR scan	Display the AR scanning camera menu page	Success
	Selecting the tutorial menu	Displays a tutorial page on how to use the app	Success
	Selecting About Menu	About app developer page and app decryption	Success
	Selecting Exit Menu	Displays app exit access	Success

Table 2 Markerless AR Scan Menu Test Results

Test Class	Test Scenario	Expected Results	Results
AR Scan Menu	Selecting AR Scan Menu	Display the AR scan camera menu page	Success
	Detecting the ground plane	Display the square mark of the detected ground plane	Success
	Object Description	Display a description of the 3d object displayed	Success
	Object Rotation Button	Make the object rotate	Success
	Information Button	Display detailed information of 3d objects.	Success
	Audio Button	Turn audio on and off.	Success
	Back Button	Return to the main menu page	Success

Table 3 Markerbase Scan AR Menu Test Results

Test Class	Test Scenario	Expected Results	Results
AR Scan Menu	Selecting the menu AR Markerbase scanning	Display the AR scanning camera menu page	Success
	Detecting <i>marker</i>	Opens the camera and detects the marker.	Success
	Object Description	Display a description of the 3d object displayed	Success
	Object rotation button	Make the object rotate	Success
	Information Button	Display detailed information of 3d objects.	Success
	Audio Button	Turn audio on and off.	Success
	Back Button	Return to the main menu page	Success

Table 4 Material Menu Test Results

Test Class	Test Scenario	Expected Results	Results
Material Menu	select the material menu	Display the material list page	Success
	Select the material	Display the page of each material	Success
	Back Button	KReturn to the main menu page	Success

Table 5 Tutorial Menu Test Results

Test Class	Test Scenario	Expected Results	Results
Tutorial Menu	Select the Tutorial Menu	Display the tutorial menu page	Success
	Back Button	Return to the main menu page	Success

Table 6 About Menu Test Results

Test Class	Test Scenario	Expected Results	Results
About Menu	Select the About Menu	Display the about menu page	Success
	Back Button	Return to the main menu page	Success

Table 7 Ground Plane Test Results

Test Class	Test Scenario	Expected Results	Results
Marker less Ground Plane	Piston 	The system detects and displays the description 	Success
	Cylinder Block 	The system detects and displays the description 	Success
	Turbo 	The system detects and displays the description 	Success

Table 8 Land Field Scanning Distance Test Results

Test Class	Results (distance)			
	10 cm	40 cm	70 cm	150 cm
Piston	Visible	Visible	Visible	Unvisible
Cylinder Block	Visible	Visible	Visible	Unvisible
Turbo	Visible	Visible	Visible	Unvisible
<i>Crankshaft</i>	Visible	Visible	Visible	Unvisible
Cylinder Head	Visible	Visible	Visible	Unvisible

Based on the test results above, it can be concluded that the application features both the application menu and the buttons in it run well. Testing ground plane distances ranging from 10cm to less than 150 cm can run and detect the ground plane properly. The black box testing that has been carried out, the result show that "Implementation Of Augmented Reality Technology As a Learning Media For Car Engine Components" are **SUCCESS**.

4. CONCLUSION

Based on the results of the research that has been conducted, the following conclusions can be drawn:

- 1) In this study successfully developed a learning media application for car engine components using android-based augmented reality technology with the name "AR Engine".
- 2) Based on black box testing of applications that have been carried out, it shows that the features in the application run quite well from several samples that have been tested.

Based on the research that has been done, the resulting application is expected to help students understand the material provided.

5. REFERENCES

- [1] F. Daryanes, D. Darmadi and e. al, "The development of articulate storyline interactive learning media based on case methods to train student's problem-solving ability," *Heliyon*, vol. 9, no. 4, pp. 1-14, 2023.
- [2] T. Kanus, "Emotions in Media Education: How media based emotions enrich classroom," *Social Sciences & Humanities Open*, vol. 8, no. 1, pp. 1-6, 2023.
- [3] P. A. Suri, M. E. Syahputra, A. Amany and A. Djafar, "Systematic literature review: The use of virtual reality as a learning media," *Procedia Computer Science*, vol. 216, pp. 1-7, 2023.
- [4] A. M. Al-Ansi, M. Jaboob, A. Garad and A. Al-Ansi, "Analyzing augmented reality (AR) and virtual reality (VR) recent development in education," *Sosial Sciences & Humanities Open*, vol. 8, no. 1, pp. 1-10, 2023.
- [5] D. Arjoni, I. d. S. Rehder, J. Figuera and V. Emilia, "Augmented reality for training formation flights: An analysis of human factors," *Heliyon*, vol. 9, no. 3, pp. 1-18, 2023.
- [6] R. Rusli, D. Nalanda, A. Tarmidi, K. Suryaningrum and R. Yunanda, "Augmented reality for studying hands on the human body for elementary school students," *Procedia Computer Science*, vol. 216, pp. 237-244, 2023.
- [7] J. Buchner and M. Kerres, "Media comparison studies dominate comparative research on augmented reality in education," *Computers & Education*, vol. 195, 2023.
- [8] J. Grodotzki, B. Muller and A. E. Tekkaya, "Introducing a general-purpose augmented reality platform for the use in engineering education," *Advances in Industrial and Manufacturing Engineering*, vol. 6, 2023.
- [9] B. Kang, N. Crilly, W. Ning and P. O. Kristensson, "Prototyping to elicit user requirements for product development: Using head-mounted augmented reality when designing interactive devices," *Design Studies*, vol. 84, 2023.
- [10] L. Kent, C. Snider, J. Gopsill and B. Hics, "Mixed reality in design prototyping: A systematic review," *Design Studies*, vol. 77, 2021.
- [11] A. Taivalsaari and T. Mikkonen, "On the development of IoT systems," *IEEE*, 2018.
- [12] H. Shima and M. Soga, "Development of an Interactive Training Support System for Drawing and Painting Skill on a 3D Object with AR and Haptic Interface," *Procedia Computer Science*, vol. 159, pp. 2015-2023, 2019.
- [13] R. Maalek, D. Lichti and J. Ruwanpura, "Robust segmentation of planar and linear features of terrestrial laser scanner point clouds acquired from construction sites," *Sensord*, 2018.
- [14] S. Nurlaily, M. Ahmad, S. Syarif, I. Idris and Stang, "Effectiveness of Augmented Reality (AR) based learning media on increasing the physical examination system of pregnant women urinary system," *Gaceta Sanitaria*, vol. 35, pp. S221-S223, 2021.
- [15] Y. Tsuyoshi, T. Matsuodani and K. Tsuda, "A Test Analysis Method for Black Box Testing Using AUT and Fault Knowledge," *Procedia Computer Science*, vol. 22, pp. 551-560, 2013.
- [16] IPA, "Report of industry actual survey for Embedded Software in 2009," *METI*, 2009.